8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

SINGLE-PHASE METAMATERIAL (SPM) AS A DISSIPATER FOR ATTENUATION OF VIBRATION IN TWO-DIMENSIONAL ELASTODYNAMICS PROBLEMS

Alireza KARKABADI
M.Sc. Student of Earthquake Engineering, Faculty of Civil Engineering, Semnan University, Semnan, Iran
alireza_karkabadi@semnan.ac.ir

Fatemeh HOSSEINI
M.Sc. Student of Earthquake Engineering, Faculty of Civil Engineering, Semnan University, Semnan, Iran
fhosseini@semnan.ac.ir

Mohammad Iman KHODAKARAMI
Assistant Professor of Earthquake Engineering, Faculty of Civil Engineering, Semnan University, Semnan, Iran
khodakarami@semnan.ac.ir

Keywords: Metamaterial, Single phase, Attenuation, Frequency gap, Wave propagation

The propagation of waves at different frequencies can be controlled using metamaterials. In general, a metamaterial cell consists of an inner core with a large mass and a high hardness and an external sheath with low mass and stiffness. These cells are arranged to form an interconnected chain and cause a reduction in vibration by creating a frequency vacuum. In 2014, the laboratorial investigations of Yan and colleagues in the field of implementing metamaterials in structure's foundation indicate appropriate performance of this system. In 2017, Maleki and Khodakarami (2017) investigated the use of metamaterial in soil to improve seismic performance and reduce in topography vibration.

Wagner et al. (2016) investigated a more accurate examination on the use of metamaterials presented relations for the calculation of the frequency vacuum band that causes the vibration reduction. Single phases are another type of metamaterials, in which the inner core and its outer sheath are of the same kind, and the creation of specific geometries has caused the formation of metamaterial cells. Figures 4, 5 and 6 have investigated the use of single-phase metamaterials to reduce the variation.

This study investigated the use of SPM to reduce the vibration of a steel plate. The creation of SPM matches the general principles of metamaterials based on the existence of an internal core and an external sheath on steel plates is done using CNC cutting. An example of SPMs is shown in Figure 1. The method of conducting research in finite element software is that a rectangular steel plate with dimensions of 165×105 mm has been investigated by the fixed boundary conditions in two length (see Figure 3). A stimulation according to Figure 2 has been applied to the median 1/3 of the plate's width, and the responses are taken on the other side.

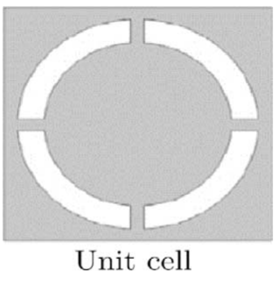

Figure 1. Single phase metamaterial.

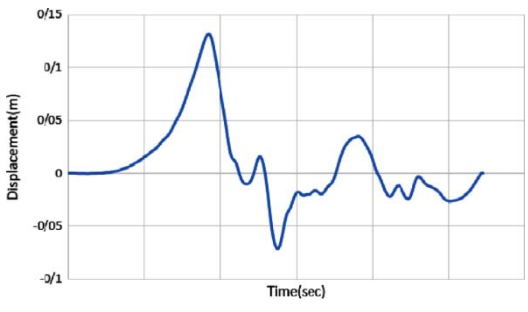

Figure 2. Stimulation used of a steel plate.

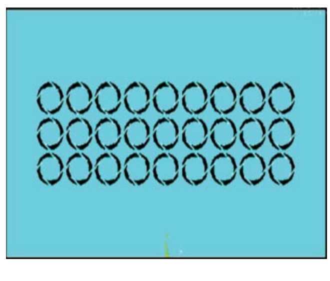

Figure 3. Geometry of SPM in this study.

In order to investigate the performance of SPM in this study, different geometries of metamaterial cell as well as arrangement and layout of these cells were simulated. Displacement contour of a steel plate without the presence of SPM with reinforced steel plate by SPMs is shown in Figures 4 and 5. The Results show the vibration reduction up to 60%. Due to the investigations, the use of single-phase metamaterials to reduce vibration in elastodynamic problems is totally appropriate.

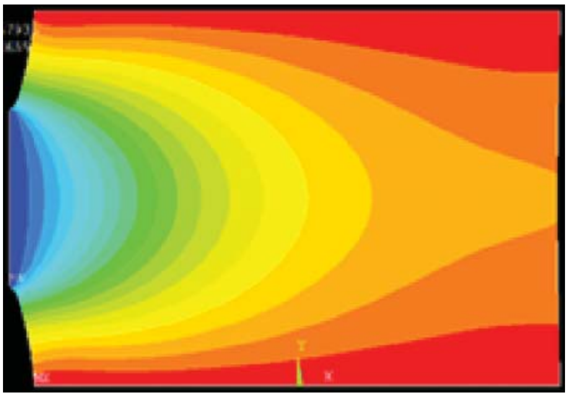

Figure 4. Steel plate without using metamaterial.

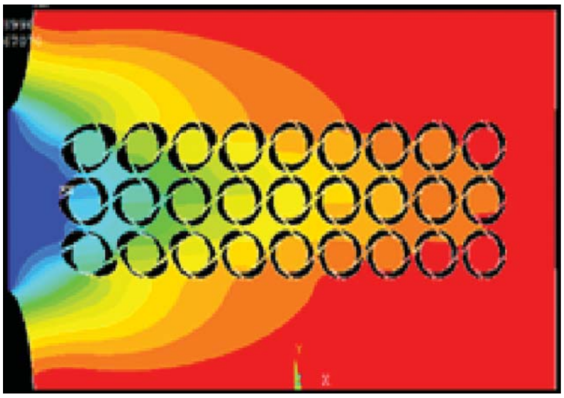

Figure 5. Steel plate with using metamaterial.

REFERENCES

Krushynska, A.O., Miniaci, M., Bosia, F., and Pugno, N.M. (2017). Coupling local resonance with Bragg band gaps in single-phase mechanical metamaterials. *Extreme Mechanics Letters*, *12*, 30-6.

Liu, X.N., Hu, G.K., Huang, G.L., and Sun, C.T. (2011). An elastic metamaterial with simultaneously negative mass density and bulk modulus. *Applied Physics Letters*, *98*(25), 251907.

Maleki, M. and Khodakarami, M.I. (2017). Feasibility analysis of using MetaSoil scatterers on the attenuation of seismic amplification in a site with triangular hill due to SV-waves. *Soil Dynamics and Earthquake Engineering*, *100*, 169-82.

Wagner, P.R., Dertimanis, V.K., Chatzi, E.N., and Antoniadis, I.A. (2016). Design of metamaterials for seismic isolation. *Dynamics of Civil Structures*, *2*, 275-287.

Yan, Y., Laskar, A., Cheng, Z., Menq, F., Tang, Y., Mo, Y.L., and Shi, Z. (2014). Seismic isolation of two dimensional periodic foundations. *Journal of Applied Physics*, *116*(4), 044908.

Zhu, R., Liu, X.N., Hu, G.K., Sun, C.T., and Huang, G.L. (2014). Negative refraction of elastic waves at the deep-subwavelength scale in a single-phase metamaterial. *Nature Communications*, *5*, 5510.